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New Details to Relaxation Dynamics of Dielectric Composite Materials Comprising Longitudinally Opened Carbon Nanotubes

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Abstract

© 2017 American Chemical Society. The difference between intact and longitudinally opened multiwalled carbon nanotubes (referred to as CNT and OCNT) has been studied in their application as conductive filler in polymer composite materials. The dielectric properties have been studied in a broad frequency range at the temperatures varying from 293 K through 373 K. Introduction of as little as 0.5% and 1.0% of the conductive filler dramatically increased both parts of the complex permittivity. The percolation threshold is registered at ~1.5% filling fraction. The main frequency dispersion of the dielectric permittivity lies in the low frequency end of the tested spectrum: from 10 2 Hz through 10 4 Hz. At equal filling fractions, the permittivity of the OCNT-based samples exceeds that of the intact CNT-based samples. The relaxation dynamics is largely affected by the nanoscale geometry of the filler: the temperature dependence of such parameters as dielectric strength, activation energy, and relaxation time demonstrated significant difference between the charge transfer mechanism in the CNT-based and OCNT-based samples. The obtained activation energy is 150 and 85 kJ/mol for materials comprising CNTs and OCNTs, respectively. The relaxation mechanism is complex, and the exact factors behind the macroscopic dielectric properties of the tested materials cannot be singled out with certainty. Several experimental data points suggest that the individual nanotubes, not their aggregates, play the major role in the observed electrical properties of the composites. At the low loading fractions, we attained the highest dielectric strength values among all the data reported by the present day for the CNT/polymer host systems.

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